ST1F

03

I

E7.4-10614

CR-138723

Evaluation of ERTS-1 imagery for mapping Quaternary deposits and landforms in the Great Plains and Midwest

(SR 238)

Roger B. Morrison
U. S. Geological Survey
Denver, Colorado 80225

George R. Hallberg
Iowa Geological Survey
Iowa City, Iowa 52240

1 November 1973

Type I Progress Report for period 1 July - 31 October 1973

Prepared for:

Goddard Space Flight Center
Greenbelt, Maryland 20771

(E74-10614) EVALUATION OF ERTS-1 IMAGERY FOR MAPPING QUATERNARY DEPOSITS AND LANDFORMS IN THE GREAT PLAINS AND MIDWEST Progress Report, 1 (Geological Survey) 8 p HC $4.00 CSCL 08B

N74-27789

G3/13

Unclas

00614

8

Type I Progress Report

ERTS-1

A. Evaluation of ERTS-1 imagery for mapping Quaternary deposits and landforms in the Great Plains and Midwest. ERTS-A Proposal No. SR 238.

B. GSFC ID No. of Principal Investigator: IN 404

C. Problems encountered: None (See 1 July 1973 Type II report).

D. Accomplishments during the reporting period:

All ERTS-1 images received during the reporting period for the six-state region of this project continued to be indexed and evaluated the following in terms: their coverage of the 24 potential study areas, cloud cover, contrast, resolution, atmospheric degradation, other defects, and the geologic terrain features displayed. Copies of the evaluation sheets were sent to each State Geologist, describing and evaluating the ERTS-1 images we have received for his State.

Phases 1 through 5 of our six-phase program of analysis (see Appendix) were in progress for various study areas.

Phase-1 results

Phase-1 analysis consists of the interpretation of landform and land-use characteristics and surficial geologic materials from the ERTS-1 images alone, without using additional data. All of the phase-1 maps are prepared as overlays to 1:1 million-scale enlargements of the ERTS-1 images. Examples of phase-1 maps of various study areas have been given in the 1 January 1973 Type II Progress Report and in the 1 March and 1 May 1973 Type I Progress Reports.

Topographic information obviously is needed for optimum identification and mapping of landforms. In airphoto interpretation, this information is easily obtained by stereoscopic viewing. Unfortunately, the ERTS images provide only a limited capability for such viewing. Stereoscopic viewing is not possible in the 10% end-lap of consecutive frames along a track (the same scan lines appear in the overlapping areas of both frames). Stereoscopic viewing is possible where adjacent orbital tracks overlap, providing side-lap stereoscopic coverage. However, such coverage represents only a small percentage of each frame. Furthermore, the limited parallax resulting from the high orbital altitude, together with the low relief in most of the Great Plains-Midwest, severely restricts the usefulness of stereoscopic viewing of ERTS images for geologic terrain interpretation in this region. Consequently, landforms must be interpreted largely from land uses.

Land uses can be deduced from tonal (gray level or image density), pattern, and "textural" variations in the images. Landforms and landform associations are interpreted primarily from agricultural patterns, including not only field patterns, but also the patterns of pastureland, woodlands, and rural roads. The sizes of fields and the regularity of their shapes (square or rectangular vs. irregular) are controlled by the topography. Concentrations of very large (greater than 160 acres) fields with regular shapes and sharp boundaries generally indicate areas of very low relief and low drainage density, such as broad flood plains and flat or gently undulating tabular uplands. The distribution of woodlands provides much information on the character of valleys and escarpments. In the areas of good soils, woodlands are restricted to slopes too steep to be farmed, i.e., the steeper valley sides. In the more arid parts of the region the steeper slopes commonly are partly woodland or brushland and partly pastureland.

Landform characteristics also can be interpreted indirectly from analysis of stream density, stream dissection and drainage patterns, and stream-divide relations--again, mainly as revealed by land-use patterns, supplemented where possible by stereoviewing. It is important to make these higher conceptual levels of landform interpretations, because only through them is it possible to detect anomalies that may point to the more ancient and obscure features we are looking for, such as traces of ancient moraines and buried river valleys. However, detecting landform anomalies from ERTS images is more difficult in the Great Plains-Midwest than in regions of higher relief, less vegetative cover, and less atmospheric haze.

Interpretation of the surficial geologic materials involves secondary and tertiary levels of inference, including various kinds of ground control; hence, specific interpretations cannot be made at the phase-1 level but must await the higher phases of analysis. Nevertheless, some general inferences obviously can be made at the phase-1 level, for example, where the landform morphology indicates the underlying materials, such as alluvial lowlands and sand dunes.

During the reporting period, phase-1 studies were completed for the following $1° \times 2°$ quadrangles (discussed below): Belleville (Ill.), Moberly (Mo.), and Nebraska City (Nebr., Mo., Iowa). Phase-1 mapping during this period totalled about 22,500 square miles (about 36,200 km^2).

Belleville (Ill.) study area

The uplands are moderately to deeply dissected by tributaries of the Mississippi, Wabash, and Ohio Rivers. The entire area was glaciated one or more times during the middle and possibly early Pleistocene, most recently in Illinoian time. The glacial deposits continue beyond the southern boundary of this study area. The thickness of Pleistocene deposits is variable; the deposits appear to be relatively thin in places, because strip-mined areas are clearly visible on the ERTS imagery. Analysis of drainage and divide patterns suggests a possible moraine-controlled divide of middle Pleistocene age, and also suggests that a bedrock structural (and topographic) high occurs in the central part of the quadrangle. Extensive lowlands along the stream valleys in the southern, mainly southeastern, portion of the study area are interpreted as probable lake basins of late Quaternary age.

Images used for the phase 1 map of the Belleville (Ill.) study area are: 1972 - 1052-16050 (13 Sept.): 1070-16050 (1 Oct.): 1071-16104, 1071-16111 (2 Oct.): 1088-16052 (19 Oct.): 1973 - 1232-16061, 1232-16063 (12 Mar.): 251-16122 (31 Mar.): 1285-16001, 1285-16004 (4 May): 1322-16054 (1 June).

Nebraska City (Neb., Iowa, Mo.) and Moberly (Mo.) study areas

These 1° x 2° quadrangles adjoin the Kansas City study area on the north and east. The Missouri River flows from north to south through the western part of the Nebraska City quadrangle, then southeast through the Kansas City and south-western third of the Moberly quadrangles. Dissection by this river and its tributaries has produced a landscape with relatively narrow uplands and moderately deep to locally deep valleys. The terrain changes markedly in character at the Missouri-Mississippi River divide. On the Mississippi side, uplands are much broader and valleys shallower than on the Missouri River side. Both of these study areas were glaciated repeatedly in the middle and early Pleistocene (Kansan and Nebraskan Glaciations). The drift-cover over bedrock is highly variable in thickness because of erosion since the last (Kansan) glaciation of these areas. Analysis of drainage and divide patterns suggests possible divide trends which may have been controlled by moraines of middle or early Pleistocene age. Many of the larger streams have cut deeply into bedrock, at least locally. Various strip-mine areas delineated by the phase-1 interpretation indicate areas where the drift is relatively thin. Many places where stream valleys widen anomalously probably are sites where the present stream valleys coincide with ancient buried (filled) bedrock valleys whose trends differ from those of the present valleys.

The northwest and northeast preferred orientations of many stream segments observed in the study areas in Kansas (see the 1 July 1973 Type II Progress Report and phase-3, 4, and 5 results below) were also observed in the Nebraska City and Moberly quadrangles. These patterns are, therefore, widespread and thus appears to have regional structural significance.

Images used for Nebraska City study area phase-1 map: 1972 - 1021-16333 (13 Aug.); 1057-16332 (18 Sept.); 1058-16383, 1058-16390 (19 Sept.); 1076-16384, 1076-16391 (7 Oct.); 1128-16282 (28 Nov.); 1973 - 1165-16335 (4 Jan.); 1237-16340, 1237-16342 (17 Mar.); 1273-16340, 1273-16342 (22 Apr.); 1290-16283 (9 May); 1291-16341 (10 May).

Images used for Moberly study area phase-1 map: 1972 - 1019-16220 (11 Aug.); 1055-16215, 1055-16221 (16 Sept.); 1073-16215, 1073-16221 (4 Oct.); 1128-16282, 1128-16284 (28 Nov.); 1973 - 1290-16283, 1290-16285 (9 May).

Phase-2 results

Collection of all pertinent published (and some unpublished) data has been completed for all of the study areas for which phase-1 results have been reported. These ground truth data are chiefly geologic but also include some soil data.

Phase-3, 4, and 5 results

The phase-2 data have been used in combination with phase-4 (additional interpretation of the repetitive ERTS-1 images to analyze **time-variant changes**) and phase-5 data (field studies) of several of these study areas to prepare "enhanced information maps" at 1:500,000 scale.

Parts of the Kansas City (Mo., Kans.), Manhattan (Kans.), and Nebraska City (Neb., Mo., Ia.) study areas were visited in the field. Conferences regarding the interpretation of the ERTS-1 images were held with members of the Kansas State Geological Survey.

These conferences (in conjunction with phase-2 data) form the basis for the phase-3 (and higher phase) maps.

<u>Great Bend-Hutchinson (Kans.), Manhattan (Kans.), and Kansas City (Kans., Mo.) study areas (see 1 July 1973 Type II report for phase-1 discussion):</u>

The results of phase-3, 4, and 5 analysis for these three study areas will be discussed together. For this study, the investigators consulted personnel of the Kansas Geological Survey, particularly C. K. Bayne and H. G. O'Connor, in order to evaluate the phase-1 maps against the best-available geologic information. The investigators also reviewed additional ERTS-1 images of these areas to produce enhanced information maps.

An excellent correlation was found between known areas of upper Quaternary alluvium and the "valley lowlands" on the phase-1 maps. Good correlations also were noted between the areas mapped in phase-1 as sand dunes and uplands having thick deposits of Quaternary loess, drift, and alluvium. The phase-1 mapping missed small patchy areas of drift in the southern part of the Kansas City quadrangle, probably because they are too small to have a detectable effect on land-use characteristics as depicted in the ERTS-1 images.

The larger areas where bedrock is at or near the surface were generally successfully delineated, especially in the Great Bend-Hutchinson study area. In the Kansas City study area, however, the deep, mature dissection of the weak bedrock since the ancient glaciation has resulted not only in widespread erosion of the drift and other old Pleistocene deposits, but also in the deposition of extensive colluvium on the valley slopes. Consequently, on the ERTS-1 images of the Kansas City study area it is difficult to distinguish accurately the boundaries between areas where bedrock is at or near the surface and areas where relatively thin drift and/or loess underlies the surface. Land-use patterns are less helpful in this area for making this distinction than in most other study areas.

The correlation of the phase-1 landform units with particular bedrock geologic units was somewhat difficult. The bedrock units are predominantly weak clastic rocks with few resistant "ledge-formers," and thus the boundaries between these units are not sharply defined. If the bedrock units are lumped in terms of their geomorphic characteristics--i. e., the kinds of landforms and slopes the bedrock units tend to form--then a much better correspondence can be shown with ERTS-interpreted units. The phase-3 maps will show these units.

Features of special interest in these study areas are:

(1) In the Great Bend-Hutchinson study area, two large areas mapped as having thick Quaternary deposits coincide with the filled and now abandoned Wilson and McPherson valleys. These valleys were last occupied in early and middle Pleistocene (pre-Kansan) time, when the "ancestral" lower Saline River flowed southeast instead of northeast as it does now.

(2) In the Manhattan-Kansas City study areas several anomalous valley widenings were mapped in phase 1. These were interpreted as sites where the present stream valleys coincide with an ancient filled valley cut in bedrock. During phase-3 analysis, the investigators, with the aid of the Kansas Geological Survey collaborators, proved that these valley widenings do indeed coincide with the buried St. Joseph valley.

(3) Several possible ancestral, moraine-controlled trends were recognized after analysis of drainage and divide patterns. One of these trends extends from the northeastern part of the Manhattan quadrangle into the southwestern part of the Kansas City quadrangle. It is an extension (from the Lincoln (Nebr.) study area) of the Cedar Bluffs relict morainic system of Nebraska. The second possible relict moraine trend extends southeastward from the Lincoln quadrangle into the northwest part of the Kansas City quadrangle and then swings northeastward to meet the Missouri River at the bend near St. Joseph, Missouri. Although field data are limited, our collaborators in the Kansas Geological Survey believe that this trend coincides with the southern terminus of drift of Nebraskan age.

(4) The ERTS imagery provides an unprecedented synoptic view of regional drainage patterns. It shows certain "preferred" directions of stream-valley alinements that recur throughout the area and suggest the likelihood of bedrock structural control. Two dominant sets of alinements were delineated on the phase-1 maps (see the 1 July 1973 Type II Progress Report), a northwest set and a northeast set. Information from our collaborators in the Kansas Geological Survey established that these sets are parallel to many known faults and folds in this region, some which are known only in the Precambrian basement rocks. However, the valley alinements occur throughout the entire area, not just in areas of well-defined known structures. The regional aspect of these alinements and their prevalence was not fully recognized before the studies with the ERTS imagery. Conventional topographic maps emphasize the stream courses within the valleys (particularly in areas of low relief, such as this), whereas ERTS images emphasize the trends of the valleys; consequently, the images better reveal the linear trends that may be structurally controlled. More complete knowledge about these linear features will be of great importance to those exploring for ground water and for oil and gas.

Plans for next reporting period

1) Completion of the phase-3 through phase-6 studies in all previously reported study areas. This includes meeting with personnel of the Missouri, Illinois, South Dakota, and Nebraska State Geological Surveys to develop the final enhanced information maps.
2) Preparation of the draft of the Type III (final) report on the project.

E. Significant results and their practical applications:

Maps at 1:1 million scale exemplifying the first phase of the investigation (which consists of the identification and mapping of landform and land-use characteristics and surficial geologic materials directly from the ERTS-1 images without use of additional data) were prepared during this reporting period for three study areas (mostly 1° x 2° in area): one in Missouri, one in Nebraska, Missouri, Iowa, and one in Illinois. Collection of pertinent published (and some unpublished) geologic-terrain data has been completed for 17 areas which have been selected for study in the six-state project region. These ground truth data are being used in combination with additional interpretation of the repetitive ERTS-1 images (including analysis of time-variant changes) to prepare "enhanced information maps" of most of these areas at 1:1 million or 1:500,000 scale.

For areas that have not been mapped at 1:500,000 or larger scales, our maps will provide the first moderately detailed information on landform features and surficial materials. Much of the information mapped is significant for exploration and development of ground water (and, locally, petroleum) and for applications in engineering and environmental geology, including land-use planning. Analysis of drainage patterns, stream-divide relations, and land-use patterns has revealed several possible moraine-controlled divides of middle and early Pleistocene age. One is an extension of the Cedar Bluffs moraine of southeastern Nebraska. Another of these divides may correspond to the terminus of Nebraskan drift in the Kansas City study area. The trends of parts of various ancient filled valleys also have been identified by analysis of changes in width of the present stream valleys. The alinements of certain segments of stream valleys in Kansas and Missouri appear to be controlled by regional faults or other structural features.

F. Published articles, etc. released during the reporting period:

Morrison, R. B., and Hallberg, G. R., 1973, Mapping Quaternary landforms and deposits in the Midwest and Great Plains by means of ERTS-1 multispectral imagery: National Aeronautic and Space Administration--Symposium on significant results obtained from ERTS-1, March 5-9, 1973, Goddard Space Flight Center, Greenbelt, Md.; NASA SP-327, Vol. 1, Tech. Presentations, sec. A, p. 353-361.

G. Recommendations: None.

H. Changes in standing order forms: None.

I. ERTS image descriptor forms: See Type I Progress Report of 1 March 1973.

J. Data request forms submitted: None.

K. N/A.

APPENDIX

This project uses a six-phase program of interpretation and analysis of the ERTS-1 images:

Phase 1 consists of preliminary mapping of the pertinent geologic and geomorphic features using only the ERTS-1 imagery.

Phase 2 involves compilation of available published and unpublished ground truth data (geologic, soil, topographic, etc.), preferably on a map of the same scale as that prepared for phase 1, without using ERTS data.

Phase 3 is a comparison of phase 1 and 2 products, with additional photointerpretation, to prepare an enhanced information map (at scales ranging from 1:1 million to 1:250,000, as appropriate), noting any differences and anomalies.

Phase 4 consists of additional analysis made from ERTS repetitive coverage of the area, noting added information (at least the differences in information content) gained from time-variant phenomena such as changes in vegetation, soil moisture, snow cover, and plowing of croplands.

Phase 5 consists of appropriate field studies to obtain necessary additional ground-truth data, particularly to evaluate anomalies and interesting new features found in phases 3 and 4.

Phase 6 is the delineation of the new information detected from the ERTS imagery.